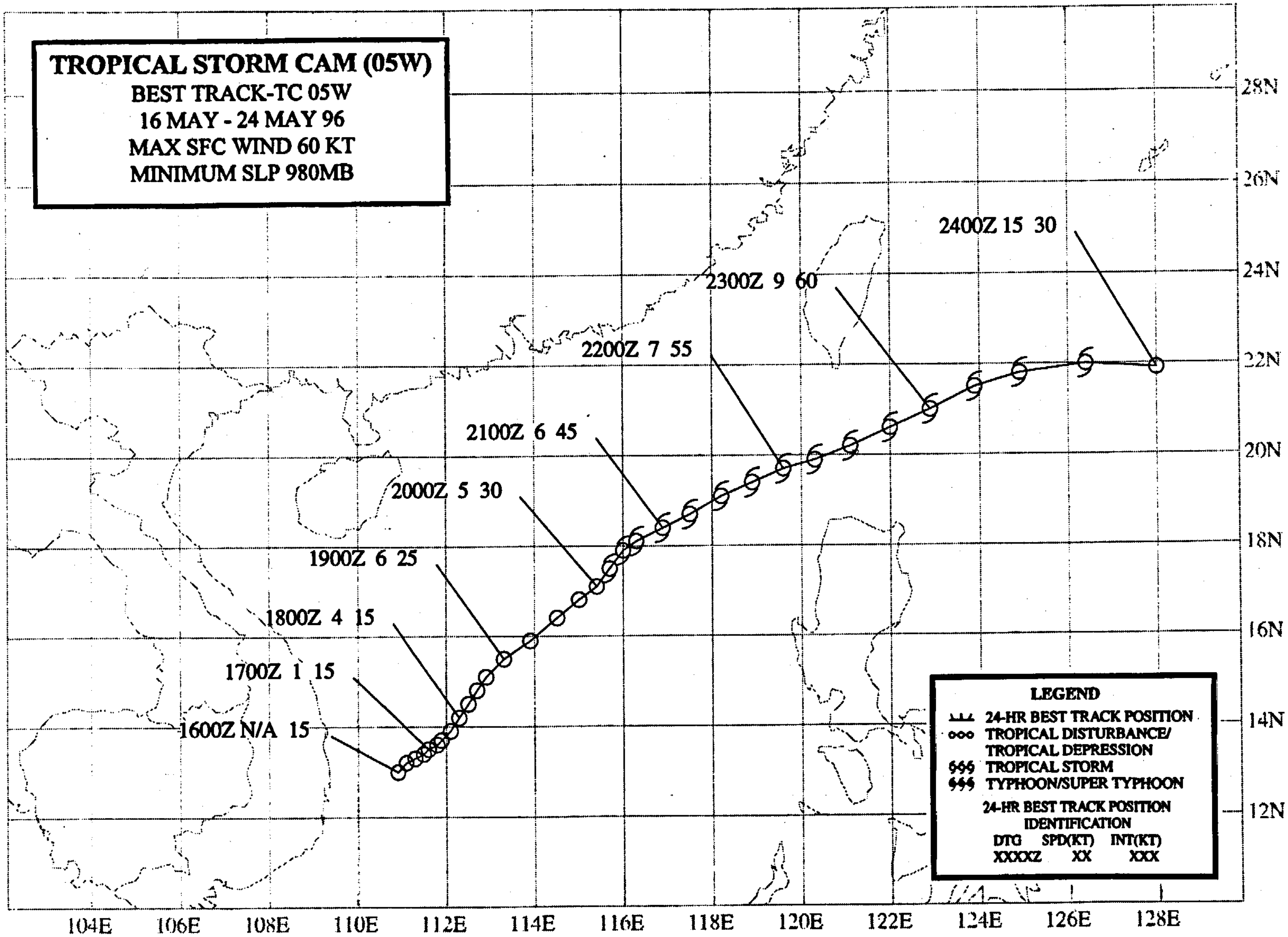
TROPICAL STORM CAM (05W)
BEST TRACK-TC 05W
16 MAY - 24 MAY 96
MAX SFC WIND 60 KT
MINIMUM SLP 980MB
2400Z 15 30
2300Z 9 60
2200Z 7 55
2100Z 6 45
2000Z 5 30
1900Z 6 25
1800Z 4 15
1700Z 1 15
1600Z N/A 15
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/ TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XXX
28N
26N
24N
22N
20N
18N
16N
14N
12N
104E
106E
108E
110E
112E
114E
116E
118E
120E
122E
124E
126E
128E

TROPICAL STORM CAM (05W)

I. HIGHLIGHTS

Originating from a monsoon depression in the South China Sea (SCS), Cam moved toward the east-northeast for its entire life. While at peak intensity, it passed through the Luzon Strait and then slowly weakened as it drifted eastward into the Philippine Sea and dissipated.

II. TRACK AND INTENSITY

As Typhoon Bart (04W) was moving eastward while located south of Japan, cloudiness began to increase in the southwesterly monsoon flow across the SCS and extended east-northeastward toward Bart. Most of the deep convection associated with this monsoon flow was located within the SCS in the form of a large ensemble of mesoscale convective systems (MCS). The ensemble of MCSs showed some signs of low-level organization around a weak low-level cyclonic circulation, and extensive cirrus outflow indicative of anticyclonic outflow aloft. These structural attributes are typical of a monsoon depression (see Appendix A and the Discussion). The system was first mentioned on the Significant Tropical Weather Advisory valid at 170600Z May. Remarks on this advisory included:

" . . . An area of convection is located [in the South China Sea]. . . . Satellite imagery and synoptic data indicate an area of strong convergence being driven by monsoon flow in a sharp trough. . . ."

The organization of the deep convection within this monsoon depression slowly improved, and a Tropical Cyclone Formation Alert was issued valid at 181630Z. The broad circulation center of this system, as defined by low-level cloud lines and by the center of symmetry of the extensive cirrus outflow, appeared to be drifting very slowly toward the northeast.

Further improvements in the low-level organization coupled with a consolidation of persistent convection closer to the low-level circulation center (Figure 3-05-1) prompted the JTWC to upgrade the system to Tropical Depression (TD) 05W on the warning valid at 181800Z. Slow northeastward motion was occurring (and was forecast to continue), as deep southwesterly monsoonal flow dominated the steering.

During the daylight hours of 20 May, the convection near the center of TD 05W increased and deepened (i.e., expanded and became colder on infrared satellite imagery). The primary and peripheral cloud bands became more tightly curved and better organized around the low-level circulation center (LLCC) (Figure 3-05-2). Given these improvements in the satellite signature, TD 05W was upgraded to Tropical Storm Cam on the warning valid at 200600Z. Motion continued toward the northeast under the influence of southwesterly steering that was dominated by strong monsoon southwest winds to the south of the system.

Continuing on a relatively slow east-northeast track, Cam intensified. The peak intensity of 60 kt (31 m/sec) occurred as Cam moved through the Luzon Strait on the morning of 23 May. At this time, infrared satellite imagery (Figure 3-05-03a) indicated a tightly wound primary cloud band, and visible satellite imagery (Figure 3-05-03b) indicated the presence of a ragged eye.

After passing through the Luzon Strait, Cam accelerated eastward within deep westerly flow in the subtropics. It also weakened under the influence of westerly shear. The final warning was issued valid at 240000Z as the remnants of Cam entered the mei-yu front (which stretched eastward from Taiwan) and dissipated.

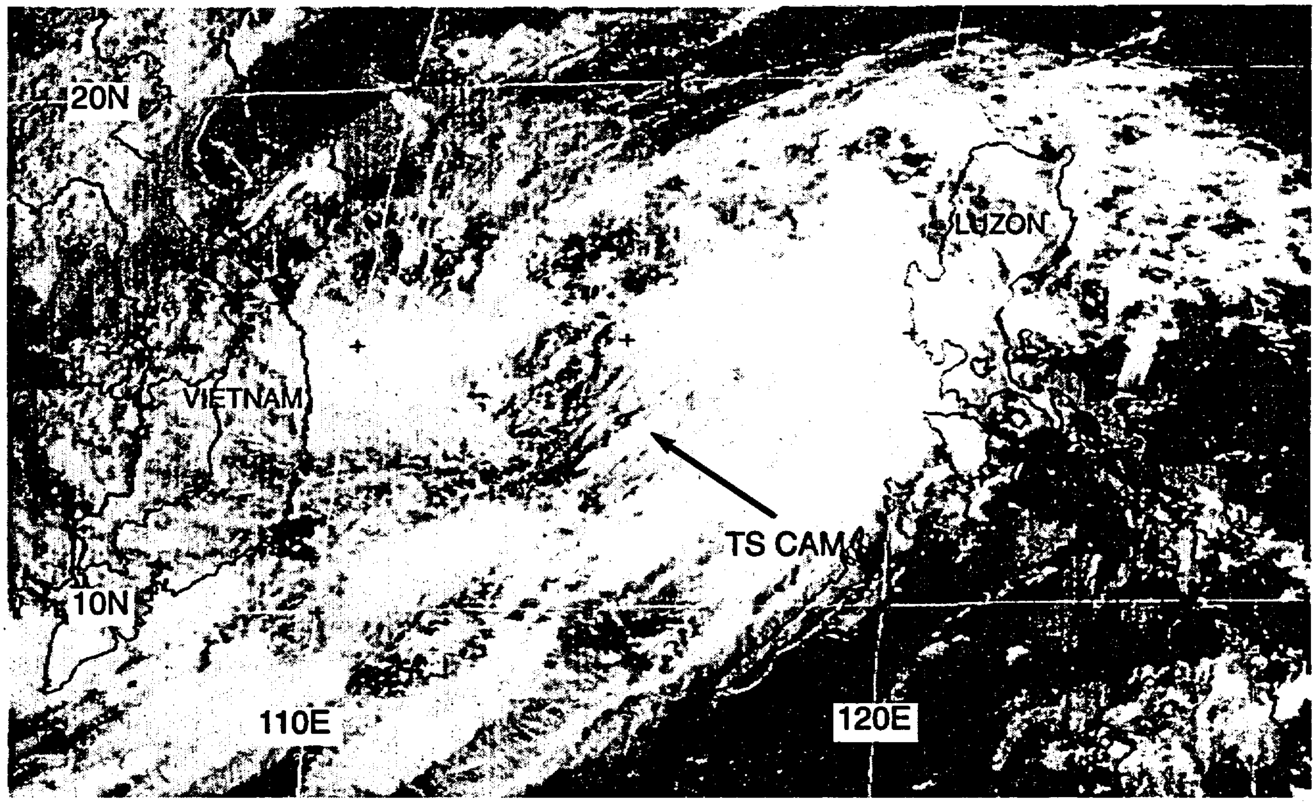

Figure 3-05-1 Near the time of the first warning, the disturbance that became Cam is organized as a monsoon depression (182331Z May visible GMS imagery).

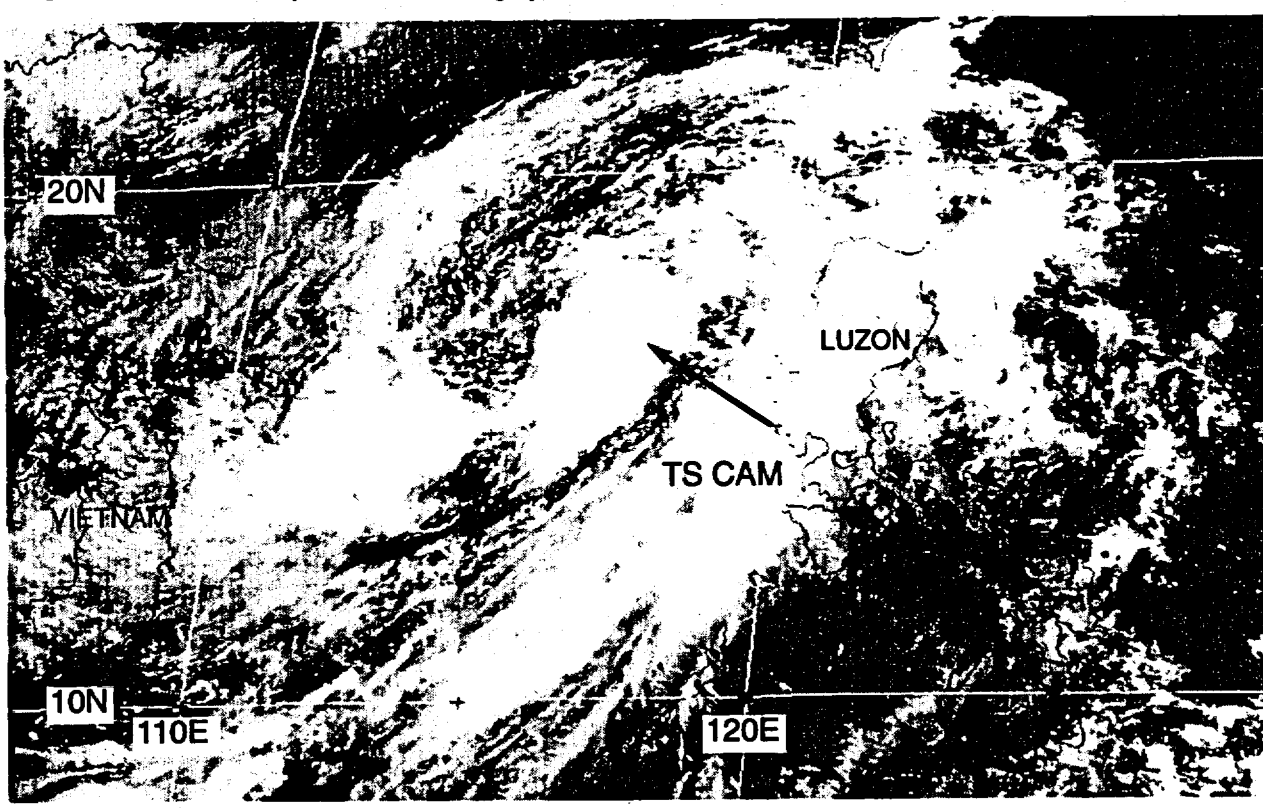

Figure 3-05-2 Deep convection has consolidated near the low-level circulation center marking the transition of the pre-Cam monsoon depression into a tropical storm (192331Z May visible GMS imagery).

III. DISCUSSION

a. *The Monsoon Depression*

Dvorak (1975, 1984) developed techniques for estimating the intensity of TCs from satellite imagery. His techniques are now used worldwide. The TC pattern types identified by Dvorak will be referred to as conventional TCs. In the Dvorak classification scheme, persistent deep convection must be located near the LLCC in order to initiate classification. The intensity of the TC is determined by several properties of the deep convection (e.g., the proximity of the low-level circulation center to the deep convection, the size of the central dense overcast, the cloud-top temperatures and

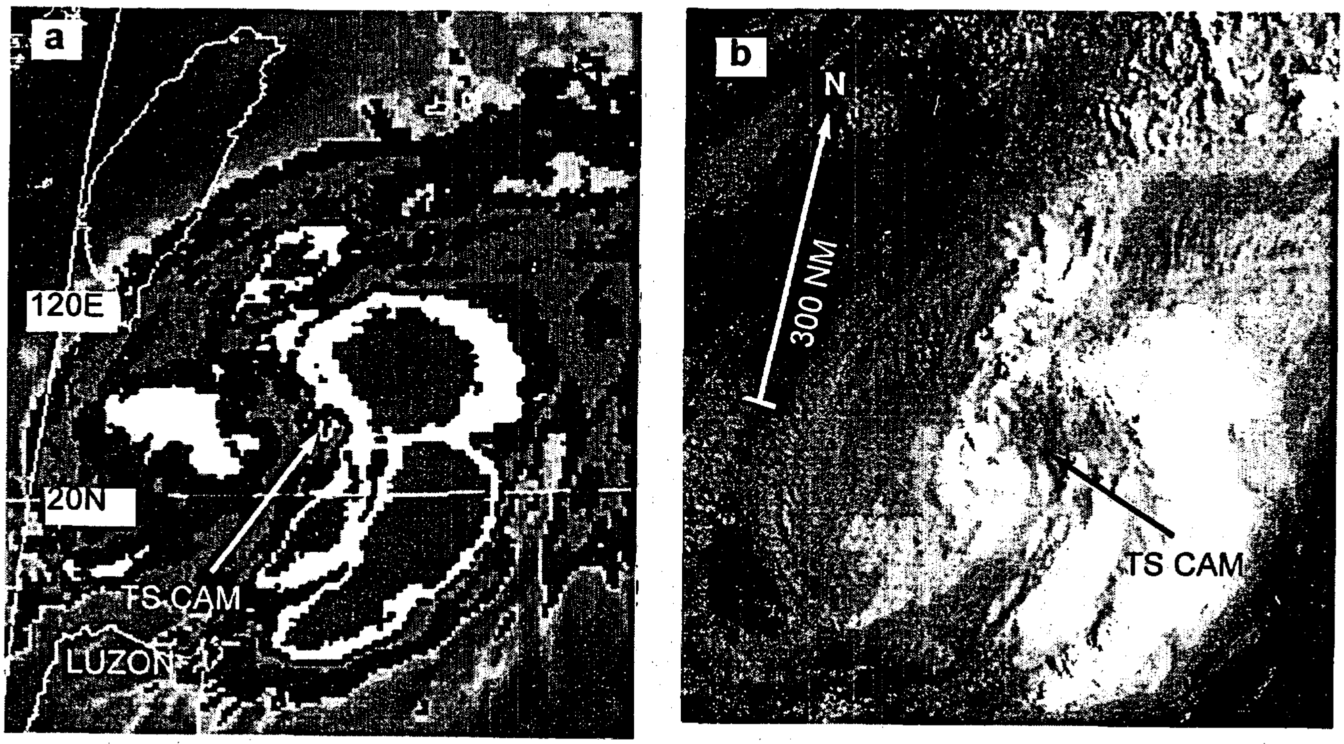

Figure 3-05-3 Cam at peak intensity: (a) 222331Z May enhanced infrared GMS imagery, and (b) 222331Z May visible GMS imagery.

horizontal width of the eye wall cloud, the width and extent of peripheral banding features). The basic TC data types identified by Dvorak are:

1) the "curved band" pattern (Figure 3-05-4a, b);
2) the "shear" pattern (Figure 3-05-4c, d);
3) the "central dense overcast" pattern (Figure 3-05-4e, f); and,
4) the "eye" pattern (Figure 3-04-4g, h).

This set of basic TC data types comprise the suite of conventional TCs.

Some conventional TCs that form in the WNP start out as monsoon depressions. The monsoon depression is a type of cyclone in the tropics that differs in several ways from the conventional types of TCs as described in Dvorak's work. The canonical monsoon depression forms over the northern Bay of Bengal in summer, and tracks west-northwestward across northeastern India (Ramage, 1971). These monsoon depressions have been studied for decades (e.g., Ramanathan and Ramakrishnan, 1932; Desai and Koteswaram, 1951; and Ramaswamy, 1969). Later, it was realized that monsoon depressions with structures similar to those of the Indian monsoon depressions occur in the Australian tropical region (Davidson and Holland, 1987), in the tropics of the western North

Pacific (JTWC, 1993), and over the deep tropics of Africa. The monsoon depression differs from conventional TCs in some respects:

1) very large size (the outer-most closedisobar may have a diameter on the order of 1000 km);

2) a lack of persistent deep convection near the LLCC (most of the deep convection in monsoon depressions is loosely organized in clusters or bands displaced from a few to several hundred kilometers from the low-level circulation center); and,

3) a low-level wind distribution that features a 200-km diameter light-wind core which may be partially surrounded by areas of gales or even storm force winds.

Because of the structure of monsoon depressions (e.g., their lack of persistent central deep convection), the use of Dvorak's techniques to estimate their intensity may be a misapplication. When applied to monsoon depressions, Dvorak's techniques yield intensities which are below the maximum winds that are usually present in areas displaced a few hundred kilometers from the LLCC. The intensity estimates yielded by Dvorak's techniques for monsoon depressions may, however, be representative of the lighter winds near their LLCCs.

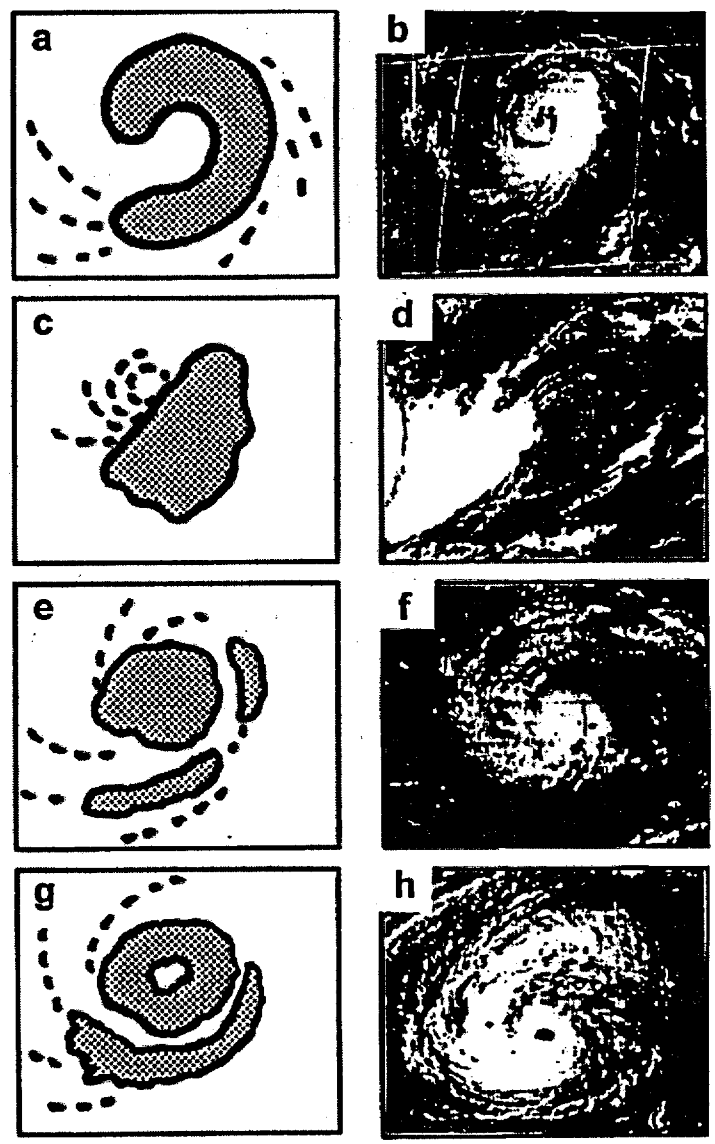

Figure 3-05-4 Schematic illustration (left column) and representative satellite imagery (right column) of Dvorak's (1975) basic tropical cyclone data types: (a,b) the "curved band" pattern; (c,d) the "shear" pattern; (e,f) the "central dense overcast" pattern; and, (g,h) the "eye" pattern.

Monsoon depressions can evolve into conventional TCs. As they slowly intensify, many monsoon depressions observed over the WNP eventually acquire persistent central deep convection and become conventional TCs. An unresolved question remains concerning the transition of a monsoon depression into a conventional TC: does the monsoon depression become the conventional TC, or does a conventional TC form within the circulation of the monsoon depression?

Cam began as a monsoon depression in the South China Sea. Initially it was a large ensemble of mesoscale convective systems embedded within a region of lowered sea-level pressure. It lacked persistent central deep convection, and the maximum winds in the system were displaced outward from the low-level circulation center, particularly to the south where monsoonal flow was strong. Eventually, as the system moved toward the northeast, circulation intensified and persistent central deep convection became established, marking its transition to a conventional TC.

b. *Unusual motion*

Persistent eastward motion of a TC at low latitude is unusual. Cam moved eastward for its entire track: forming near 13°N in the South China Sea it moved slowly toward the east-northeast for its entire track and eventually dissipated in the subtropics at 22°N. Most cases of eastward motion of a TC at low latitude in the WNP can be attributed to the influence of the monsoon circulation on the steering flow. In Cam's case, the deep southwesterly monsoon flow to its south was, for much of its track, the dominant flow asymmetry responsible for its northeastward motion. Monsoonal influences on TC motion form an important part of Carr and Elsberry's "Systematic and Integrated Approach" to TC forecasting (see Chapter 1).

IV. IMPACT

No reports of significant damage or injuries were received at the JTWC.